Seed Layer for Solar Cell Conductive Contact

TECHNICAL FIELD

[0001] Embodiments of the present invention are in the field of renewable energy and, in particular, seed layers for solar cell conductive contacts and methods of forming seed layers for solar cell conductive contacts.

BACKGROUND

[0002] Photovoltaic cells, commonly known as solar cells, are well known devices for direct conversion of solar radiation into electrical energy. Generally, solar cells are fabricated on a semiconductor wafer or substrate using semiconductor processing techniques to form a p-n junction near a surface of the substrate. Solar radiation impinging on the surface of, and entering into, the substrate creates electron and hole pairs in the bulk of the substrate. The electron and hole pairs migrate to p-doped and n-doped regions in the substrate, thereby generating a voltage differential between the doped regions. The doped regions are connected to conductive regions on the solar cell to direct an electrical current from the cell to an external circuit coupled thereto.

[0003] Efficiency is an important characteristic of a solar cell as it is directly related to the capability of the solar cell to generate power. Likewise, efficiency in producing solar cells is directly related to the cost effectiveness of such solar cells. Accordingly, techniques for increasing the efficiency of solar cells, or techniques for increasing the efficiency in the manufacture of solar cells, are generally desirable. Some embodiments of the present invention allow for increased solar cell manufacture efficiency by providing novel processes for fabricating solar cell structures. Some embodiments of the present invention allow for increased solar cell efficiency by providing novel solar cell structures.

SUMMARY OF INVENTION

[0003a] According to the first aspect of the invention a solar cell is provided, comprising:

a substrate, an emitter region disposed above the substrate and a conductive contact disposed on the emitter region and comprising a conductive layer in contact with the emitter region, the conductive layer comprising aluminum/silicon (Al/Si) particles having a composition consisting essentially of greater than approximately 15% but less than approximately 25% Si with the remainder Al, wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.

[0003b] According to the second aspect of the invention, a solar cell is provided, comprising a substrate having a diffusion region at or near a surface of the substrate; and a conductive contact disposed above the diffusion region and comprising a conductive layer in contact with the substrate, the conductive layer comprising aluminum/silicon (Al/Si) particles having a composition consisting essentially of greater than approximately 15% but less than approximately 25% Si with the remainder Al, wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.

[0003c] According to the third aspect of the invention, a partially fabricated solar cell is provided, comprising a substrate, an emitter region disposed in or above the substrate and a conductive contact disposed on a silicon region of the emitter region and comprising a conductive layer in contact with the silicon region, the conductive layer comprising aluminum/silicon (Al/Si) particles wherein the Al/Si particles have a composition consisting essentially of greater than approximately 15% Si but less than approximately 25% Si, with the remainder Al ~~having a composition consisting of a sufficient amount of Si such that the conductive layer does not consume a significant portion of the silicon region during an anneal of the conductive layer, with the remainder Al~~.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figure 1 is a plot of photoluminescence (PL) mid-point post-fire as a function of target silicon (Si) content within a paste additive, in accordance with an embodiment of the present invention.

[0005] Figure 2A is a scanning electron microscopy (SEM) image of a silicon substrate following firing of a seed paste having 15% silicon relative to aluminum therein, in accordance with an embodiment of the present invention.

[0006] Figure 2B is an SEM image of a silicon substrate following firing of a seed paste having 25% silicon relative to aluminum therein, in accordance with an embodiment of the present invention.

CLAIMS

What is claimed is:

1. A solar cell, comprising:

a substrate;

an emitter region disposed above the substrate; and

a conductive contact disposed on the emitter region and comprising a conductive layer in contact with the emitter region, the conductive layer comprising aluminum/silicon (Al/Si) particles having a composition consisting essentially of greater than approximately 15% but less than approximately 25% Si with the remainder Al,

wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.

~~2. The solar cell of claim 1, wherein the Al/Si particles have a composition consisting essentially of less than approximately 25% Si with the remainder Al.~~

23. The solar cell of claim 1, wherein the Al/Si particles are microcrystalline.

~~4. The solar cell of claim 1, wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.~~

35. The solar cell of claim 14, wherein the binders comprise zinc oxide (ZnO), tin oxide (SnO), or both, and the frit comprises glass particles.

46. The solar cell of claim 1, wherein the conductive layer has a thickness greater than approximately 100 microns, and wherein the conductive contact is a back contact of the solar cell consisting essentially of the conductive layer.

57. The solar cell of claim 1, wherein the conductive layer has a thickness of approximately 2-10 microns, and wherein the conductive contact is a back contact of the solar cell comprising the conductive layer, an electroless plated nickel (Ni) layer disposed on the conductive layer, and an electroplated copper (Cu) layer disposed on the Ni layer.

68. The solar cell of claim 23, wherein the crystallinity of the Al/Si particles results from an anneal performed at a temperature approximately in the range of 550-580 degrees Celsius.

79. The solar cell of claim 1, wherein the emitter region comprises a polycrystalline silicon region disposed on a tunneling dielectric layer disposed on the substrate, and the conductive layer is disposed in a trench of an insulator layer disposed above the emitter region and is in contact with the polycrystalline silicon region, and wherein there is negligible to no pitting of the polycrystalline silicon region where the conductive layer is in contact with the polycrystalline silicon region.

810. A solar cell, comprising:

a substrate having a diffusion region at or near a surface of the substrate; and

a conductive contact disposed above the diffusion region and comprising a conductive layer in contact with the substrate, the conductive layer comprising aluminum/silicon (Al/Si) particles having a composition consisting essentially of greater than approximately 15% but less than approximately 25% Si with the remainder Al,

wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.

~~11. The solar cell of claim 10, wherein the Al/Si particles have a composition consisting essentially of less than approximately 25% Si with the remainder Al.~~

912. The solar cell of claim 810, wherein the Al/Si particles are microcrystalline.

~~13. The solar cell of claim 10, wherein the conductive layer has a composition consisting essentially of approximately 10-30% binders and frit with the remainder the Al/Si particles.~~

1014. The solar cell of claim 813, wherein the binders comprise zinc oxide (ZnO), tin oxide (SnO), or both, and the frit comprises glass particles.

1115. The solar cell of claim 810, wherein the conductive layer has a thickness greater than approximately 100 microns, and wherein the conductive contact is a back contact of the solar cell consisting essentially of the conductive layer.

1216. The solar cell of claim 810, wherein the conductive layer has a thickness of approximately 2-10 microns, and wherein the conductive contact is a back contact of the solar cell comprising the conductive layer, an electroless plated nickel (Ni) layer disposed on the conductive layer, and an electroplated copper (Cu) layer disposed on the Ni layer.

13~~17~~. The solar cell of claim 9~~12~~, wherein the crystallinity of the Al/Si particles results from an anneal performed at a temperature approximately in the range of 550-580 degrees Celsius.

13~~18~~. The solar cell of claim 8~~10~~, wherein the substrate is a bulk crystalline silicon substrate, and the conductive layer is disposed in a trench of an insulator layer disposed above the surface of the substrate, and wherein there is negligible to no pitting of the bulk crystalline silicon substrate where the conductive layer is in contact with the bulk crystalline silicon substrate.

14~~19~~. A partially fabricated solar cell, comprising:

a substrate;

an emitter region disposed in or above the substrate; and

a conductive contact disposed on a silicon region of the emitter region and comprising a conductive layer in contact with the silicon region, the conductive layer comprising aluminum/silicon (Al/Si) particles, wherein the Al/Si particles have a composition consisting essentially of greater than approximately 15% Si but less than approximately 25% Si, with the remainder Al ~~having a composition consisting of a sufficient amount of Si such that the conductive layer does not consume a significant portion of the silicon region during an anneal of the conductive layer, with the remainder Al~~.

~~20. The solar cell of claim 19, wherein the Al/Si particles have a composition consisting essentially of greater than approximately 15% Si but less than approximately 25% Si, with the remainder Al.~~